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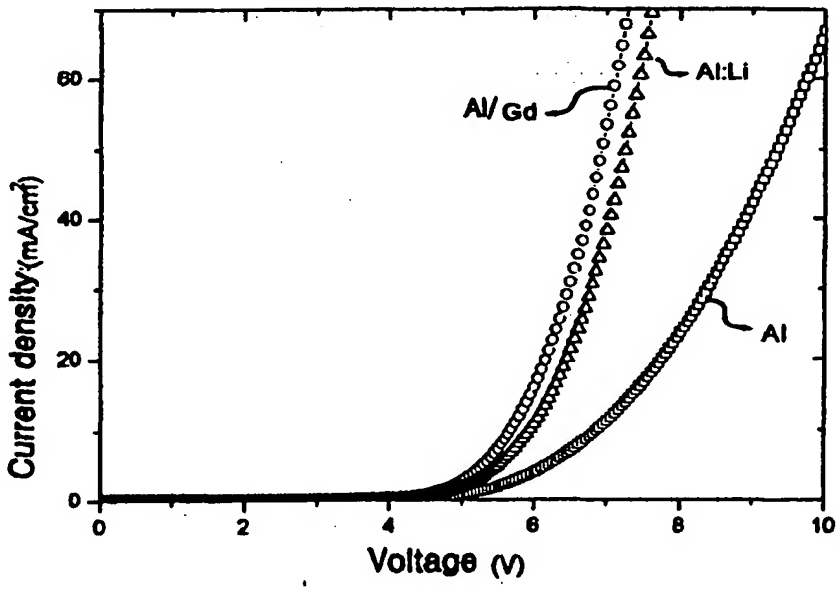
For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: ORGANIC ELECTROLUMINESCENT DEVICE HAVING A GADOLINIUM LAYER



(57) Abstract: The present invention relates to an organic electroluminescent device, and more particularly, to an organic electroluminescent device, wherein by forming an electrode (cathode) using gadolinium (Gd), which has a low electron injection barrier and can be easily processed, as an electron injection layer in the organic electroluminescent device, the operation voltage of the organic electroluminescent device can be reduced, electron injection can be facilitated to enhance the efficiency of the device, and the stable cathode electrode can also be formed.

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ORGANIC ELECTROLUMINESCENT DEVICE HAVING A GADOLINIUM LAYER

Technical Field

The present invention relates to an organic electroluminescent device, and more particularly, to an organic electroluminescent device employing a gadolinium (Gd) layer, wherein by forming an electrode (cathode) using Gd, which is a chemically stable material and can be easily processed, as an electron injection layer in the organic electroluminescent device, the operation voltage of the organic electroluminescent device can be reduced, electron injection can be facilitated to enhance the efficiency of the device, and the stable cathode electrode can also be formed.

Background Art

A cathode electrode serves to inject electrons in an organic electroluminescent device. Particularly, since the electrons are minority carriers in the organic electroluminescent device, they determine the efficiency of the device.

Accordingly, smooth electron injection functions to increase the probability of combination between the electrons and holes injected from an anode electrode as well as to reduce the operation voltage of the device, thereby enhancing the efficiency of the device.

A conventional cathode electrode used until now has been made of metals such as Ca, Al, an Al-Li alloy and a Mg-Ag alloy. Among them, a metal such as Ca chemically reacts with an organic thin film. Since Al has a relatively higher work function, the electron injection is not smoothly performed and the operation voltage of the device is increased as compared with that of other metals when Al is used for manufacture of the device. Thus, Al has not been frequently used.

Therefore, material for a cathode electrode or electron injection layer, which has a low work function, is chemically stable and can also be easily processed, is an essential element in manufacturing the electroluminescent device.

However, metals having a low work function which have been attempted to

employ until now are chemically unstable.

Although the Al-Li alloy and the Mg-Ag alloy have low work functions and are somewhat chemically stable, respectively, there is a disadvantage in that since the evaporation temperature of each element is different from one another, it is difficult to maintain a constant fraction of each element during manufacture of the cathode electrode.

Disclosure of Invention

The present invention is contemplated to solve the above problems. An object of the present invention is to provide an organic electroluminescent device employing a Gd layer, wherein the operation voltage of the organic electroluminescent device can be reduced, electron injection can be facilitated to enhance the efficiency of the device, and a stable cathode electrode can also be formed.

According to the present invention, the above object is accomplished by forming an electron injection layer out of Gd or forming the electrode out of an alloy of Gd and metal.

Brief Description of Drawings

FIG. 1 is a sectional view of a general electroluminescent device to which the present invention is to be applied; and

FIG. 2 is a comparative graph showing current density-voltage characteristics of an electroluminescent device to which the present invention is applied.

Best Mode for Carrying Out the Invetnion

Hereinafter, a preferred embodiment of the present invention will be explained in detail with reference to the accompanying drawings.

FIG. 1 is a sectional view of a general electroluminescent device to which the present invention is to be applied. The electroluminescent device is constructed in such a manner that hole and electron transport (electroluminescence) layers 3, 4 are formed out of organic material after forming an anode electrode 2 on a transparent substrate 1, and an electron injection layer 5 and a cover thin film 6 are positioned on the hole and electron

transport layers 3, 4.

This is generally expressed as a lamination structure as follows: that is, the cover thin film 6 / the electron injection layer 5 / the electron transport (electroluminescence) layer 4 / the hole transport layer 3 / the anode electrode 2 / the substrate 1.

In the operation of the device, holes injected from the anode electrode and electrons injected from the electron injection layer 5 are constrained in an the interface between the electroluminescence layer 4 and the hole transport layer 3 by energy levels, respectively, and then combined to each other so as to emit light.

According to this embodiment of the present invention, on the glass substrate 1, the hole transport layer 3 is formed out of N, N'-diphenyl-N, N'-bis (3-methyl)-1, 1'-biphenyl-4, 4'-diamine (TPD), the electron transport (electroluminescence) layer 4 is formed out of tris(8-hydroxyquinoline) Al (Alq_3), the anode electrode is formed out of ITO, and the electron injection layer 5 is formed out of Gd. Electroluminescent devices comprising the above components and the cover thin film 6, which is formed out of Al, an Al-Li alloy and an Al alloy, respectively, are manufactured and compared with one another in view of their characteristics

That is, the structure configured as follows: Al (130 nm) / Gd (20 nm) / Alq_3 (50 nm) / TPD (50 nm) / ITO (70 nm) / glass. FIG. 2 is a graph showing current density-voltage characteristics of the device according to material for the cathode electrode in the aforementioned structure. It can be seen from the figure that the current density-voltage characteristics of the device using the electron injection layer of an Gd (○) are superior to those of the devices using the electron injection layers of an Al-Li alloy (△) and Al (□).

The electroluminescent device of the present invention is formed by using Gd as the electron injection layer 5 of the high or low molecular organic electroluminescent device, and the electron injection layer 5 is formed by a vacuum thermal evaporation method or a sputtering method.

Moreover, by further providing the cover thin film 6 which is formed by coating a metal having good electrical conductivity and oxidation resistance on the electron injection layer 5 formed out of Gd, its characteristics are more enhanced. Materials used for the purpose may include Al, Cu, Cr, Ni, Au, Ag, Pt, Co, In, Mg, Pd, Ta and Mo.

In addition to the structure of the electron injection layer and the cover thin film, the cathode electrode may be formed out of an alloy of Gd and one or more metals selected from a group consisting of Ca, Li, Al, Cu, Cr, Ni, Au, Ag, Pt, Co, In, Mg, Pd, Ta and Mo.

Methods of implementing the above construction may include a method of directly heating and depositing an alloy, a sputtering method of forming a thin film by using an alloy as a sputtering target, and a method of simultaneously depositing each material as each source.

Industrial Applicability

According to the present invention, there are advantages in that the operation voltage of the organic electroluminescent device can be reduced, the electron injection can be facilitated to enhance the efficiency of the device, and the stable cathode electrode can also be formed.

CLAIMS

1. An electroluminescent device, comprising
an electron injection layer formed out of Gadolinium (Gd).

2. The electroluminescent device as claimed in claim 1, further comprising a cover thin film formed by coating a metal having good electrical conductivity and oxidation resistance on the electron injection layer formed out of Gd.

3. The electroluminescent device as claimed in claim 2, wherein the cover thin film is formed out of a metal selected from a group consisting of Al, Cu, Cr, Ni, Au, Ag, Pt, Co, In, Mg, Pd, Ta and Mo.

4. An electroluminescent device, comprising
an electrode formed out of an alloy of Gd and one or more metals selected from a group consisting of Ca, Li, Al, Cu, Cr, Ni, Au, Ag, Pt, Co, In, Mg, Pd, Ta and Mo.

FIG. 1

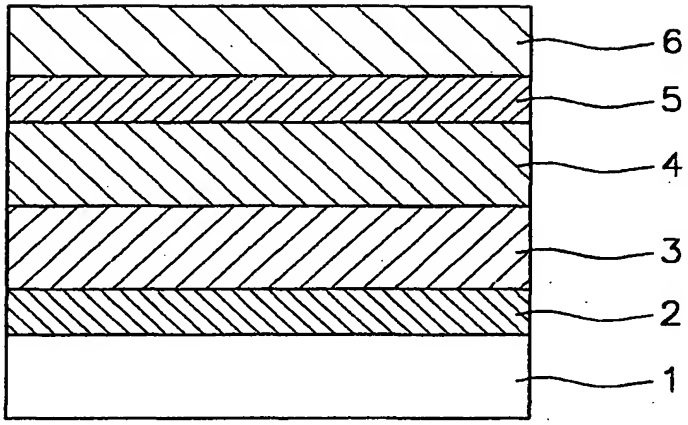
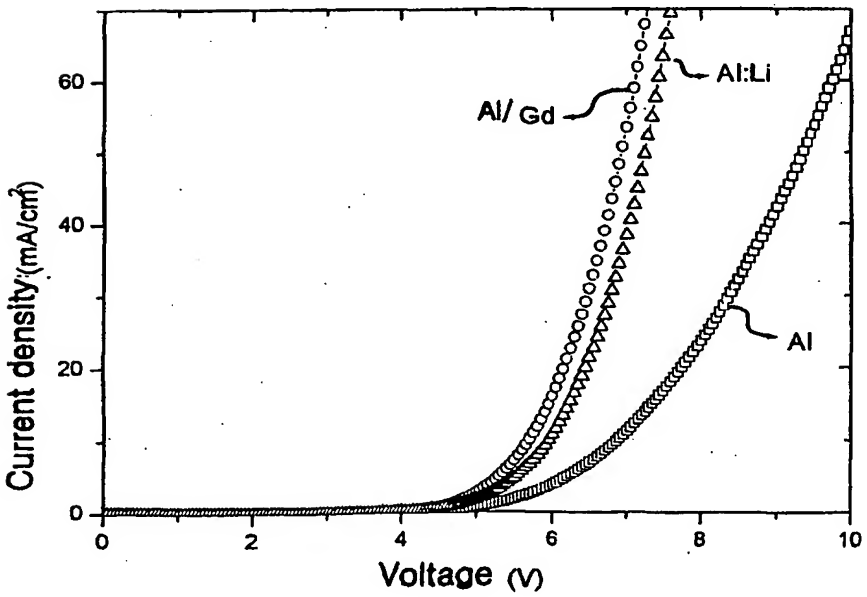

6
5
4
3
2
1

FIG. 2


Al:Li
Al/ Gd
Al
Current density(mA/cm²)
Voltage (V)
0
20
40
60
0
2
4
6
8
10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR01/01691

A. CLASSIFICATION OF SUBJECT MATTER

IPC7 H05B 33/26

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimun documentation searched (classification system followed by classification symbols)

IPC7 H05B 33/26, H05B 33/10

Documentation searched other than minimun documentation to the extent that such documents are included in the fileds searched

KOREAN PATENTS AND APPLICATION SINCE 1975
KOREAN UTILITY MODELS AND APPLICATION FOR UTILITY MODELS SINCE 1975

Electronic data base consulted during the intertnational search (name of data base and, where practicable, search trerms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
"X" "Y"	JP 10-321376 A2 (MINOLTA CO) DEC. 04, 1998 WHOLE DOCUMENT	1.4 2,3
"Y"	JP 11-026167 A2 (MITSUBISHI CO) JAN. 29, 1999 WHOLE DOCUMENT	2,3

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevence; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevence; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 JANUARY 2002 (25.01.2002)	26 JANUARY 2002 (26.01.2002)

Name and mailing address of the ISA/KR	Authorized officer
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INTERNATIONAL SEARCH REPORT

Information on patent family members

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 10-321376 A2	DEC. 04, 1998	US 6,180,217 A	JAN.30,2001
JP 11-026167 A2	JAN.29, 1999	US 6,121,727 A EP 869701 A3	SEP.19,2000 MAY.12,1999

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